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(54) A PERSONAL SAFETY SYSTEM FOR PROTECTING AN OCCUPANT OF HIGH-SPEED TRAVELLING VEHICLE

(71) We, ASAHI KASEI KOGYO KABUSHIKI KAISHA, a Japanese Company, of 25—1, 1-chome, Dojima-hamadori, Kita-ku, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with a perconal safety system for protecting an occupant of an automobile or other similar high-speed travelling vehicle against injury at the time of a collision.

In the hope of protecting the occupant of an automobile of other similar high-speed travelling vehicle against possible injuries at the time of a collision of the vehicle, there have in recent years been developed various devices in which a bag normally stowed in a folded condition is inflated to full capacity by a gas generated instantaneously at the moment of collision. The inflated bag receives and absorbs the impact of the occupant's body. In these devices, however, the inflating bag suffers from positional instability and it is not possible to ensure that the bag will receive the occupant, who may be thrown forward in various unpredictable directions, at a fixed position. In view of this and other disadvantages the protection of the occupant aimed at by these devices is not achieved completely as expected.

According to the present invention there is provided a personal safety system for an occupant of a motor vehicle comprising impact cushioning means being a sheet material, net or inflatable bag normally stowed in a folded condition and unfoldable to receive and absorb the impact of an occupants body, projecting means for projecting the cushioning means to a position in front of the occupant, guide means to stabilize the cushioning means during unfolding thereof, and a sensor adapted to actuate the projecting means on sensing an acceleration exceeding a predetermined magnitude.

The term "acceleration" is intended to include all changes of direction or speed of a vehicle caused by application of an external force.

The projecting means may be at least two tubular bags normally stowed in a folded condition and which are inflated by gas generating means actuated by the sensor. Alternatively the projecting means may be a projectile launched by gas generating means.

The impact cushioning means may be an inflatable cushioning bag which is inflated by gas generating means, preferably an additional gas generating means which has a delay detonator so that it operates after actuation of the projecting means. The impact cushioning means may also be a sheet material, such as a cloth, or a net. This is provided with means, which may be incorporated with projecting means, for tightening the sheet around the occupant.

The projecting means may either be attached directly to the impact cushioning means, so that it "pushes" the cushioning means into position, or it may be linked by a cord so that it "draws" it into position. A clamping device may be used to restrict backwards movement of the projecting means at the end of its travel so that a sheet material or net cushioning means is held tightly against the occupant.

The guide means may be a guide rail to which is slidably connected the projecting means or the impact cushioning means.

Various embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of one embodiment of the personal safety system according to the present invention, using an inflatable bag as the projecting means;

Figure 2 is a front elevation of the system of Figure 1 expanded to its operative condition;

Figure 3 is a cross section of a tubular inflatable bag intended as projecting means in the system of Figure 1;

Figure 4 is a side view of the end portion of a guide means for the system of Figure 1;

Figure 5 is a perspective view illustrating the relationship between the tubular inflatable bag member and an inflatable cushioning bag in the system of Figure 1;

Figure 6 is a cross section taken along the line A—A in Figure 5;

Figure 7 is a side elevation of another embodiment of the present invention, provided with a projectile as means for projecting the cushioning means;

Figure 8 is a front elevation of the system of Figure 7 illustrating the projectile brought to its operative condition;

Figure 9 is a cross section of the projectile for the system of Figure 7;

Figure 10 is a cross section of another embodiment of a projectile for the system of Figure 7;

Figure 11 is a cross section of one embodiment of a guide means for the system of Figure 7;

Figure 12 is a cross section of another embodiment of a guide means for use in the system of Figure 7;

Figure 13 is a side elevation of a further embodiment of the present invention, with a net or cloth used as the cushioning means and a drawing out device attached as projecting means to the net or cloth;

Figure 14 is a front elevation illustrating the system of Figure 13 unfolded to its operative condition;

Figure 15 is a fragmentary front elevation of the lower end of the net or cloth shown in Figure 14 as a cushioning means;

Figure 16 is a fragmentary cross section of Figure 15 illustrating the connection of the net or cloth cushioning means by a sliding member to the guide means;

Figure 17 is a cross section illustrating the connection of the sliding member to the cord in the guide means of the system of Figure 13;

Figure 18 is a longitudinal cross section of a direction-turning device for the cord which device is disposed at the lower end of the net or cloth of Figure 15;

Figure 19 is a cross-sectional view of Figure 17;

Figure 20 is a longitudinal cross section of the drawing device as a projecting means in the device of Figure 13;

Figure 21 is a longitudinal section of a detaching means, being part of the systems shown in Figures 13 and 22;

Figure 22 is a cross section of an embodiment of the invention employing a net or cloth cushioning means provided with a tubular inflatable bag in place of the net or cloth shown in Figure 13;

Figure 23 is a front elevation of the system of Figure 22 unfolded to its operative condition; and

Figure 24 is an outline drawing illustrating the position in a motor vehicle of the system of this invention.

Firstly the main features of the system of the present invention will be described and explained. In the system of the present invention the impact cushioning means is drawn by the projecting means, at the instant of a collision, along the guide means and caused to unfold and spread to its full capacity in front of the occupant's body. As impact cushioning means, the present invention uses either an inflatable cushioning bag 6 which is normally stowed in a folded condition as illustrated in Figures 1 and 2 and which, in an emergency, is inflated to its operative state by the gas generating means 41, or a net or cloth 120 which is normally stowed in a folded condition as illustrated in Figures 13 and 14 and which, in an emergency, may be drawn out to its operative state by the drawing means 170. As the cushioning bag 6 mentioned above, there may be used any conventional bags for example, bags of fabrics of natural or synthetic fibers, paper, synthetic resin films and rubberized fabrics which are flexible, relatively light and yet strong enough to withstand the impact of the occupant's body at the time of collision. The cushioning bag is normally stowed in a folded condition and is provided with a gas generating means communicating with its interior. The size and the shape of this cushioning bag are so selected that the bag, in its expanded state, has a width substantially equal to the width of the seat of the occupant required to be projected and the edge portions of the bag will substantially completely fill up the spaces on each side of the occupant against the back of the seat. When the projecting means is a tubular inflatable bag member as shown in Figure 1, the cushioning bag may be joined to the tubular inflatable bag at both edges or other suitable parts. When the projecting means is a projectile 40 as shown in Figure 7, the cushioning bag is attached to a cord 55.

On inflation of the cushioning bag, the air pressure inside the vehicle increases and produces an adverse effect upon the occupant. To avoid this phenomenon, there may be provided a mechanism to effect a partial break in the window glass of the vehicle. As an alternative, there may be employed a suction type air bag, i.e., the cushioning bag may be provided with suitable separating walls so that some of the resultant compartments are expanded by the pressure of gas from the gas generating means and the remaining compartments are expanded by sucking in the interior air of the vehicel through suction holes formed in

the walls of the bag thereof. Also a gas exhaust device may be employed using a pressure controlling valve to increase the cushioning effect. It is optional to employ any of these and other suitable means to provide safety against increase of internal air pressure.

As the gas source for the gas generating means 41 serving to inflate the cushioning bag 6, there may be used an explosive, a gas stored under pressure, a compressive gas, or some other chemical substance which is capable of producing a gas by a chemical reaction.

The aforementioned net or cloth 120 is preferably formed of a rubberized nylon cloth, but it may be formed of other fibrous material, film, rubber, sponge or a combination thereof as illustrated in Figure 14. This net or cloth 120 may, as illustrated for net 120*a* in Figure 23, be provided with at least two tubular inflatable bags 133 which are made of the same material as the aforementioned cushioning bag. Normally, the net or cloth is stowed in a folded condition and attached by a cord 55 to the drawing device 170 as in Figure 13. The size and the shape of the net or cloth as in Figure 14 120*a* are so selected that the net or fabric, in its unfolded and spread state, has a width substantially equal to the width of the seat of the occupant desired to be protected and the edge portions of the net or cloth will substantially completely conform to the contour of the sides of the occupant and against the back of his seat.

When the impact cushioning means is drawn by the projecting means at the moment of a collision so as to be expanded in front of the occupant, the projecting means or the cushioning means is constrained along a fixed path by the guide means. This brings the impact cushioning means correctly to its operative position in front of the occupant. In Figure 1, the guide means is indicated at 5 and guides along a predetermined path the tubular inflatable bag 3 which is thrust forward at a very high speed by the generated gas. Generally, such guide means is formed of pipes or solid bars and a sliding device e.g. 31 in Figure 3, is joined to said tubular inflatable bag members and slides on the solid bar. It may otherwise be formed with rails having a special cross section which matches that of sliding legs attached to the tubular inflatable bag member 3.

The guide means 5 may be provided at its end portion with a suitable stopper mechanism 7 adapted to bring the oncoming inflatable bag member 3 to a complete halt. As stopper mechanism 7, there may be adopted, for example, the mechanism of Figure 4 wherein clicks 71 rotatably fixed in position with pins, are held upright by virtue of the resilience of springs 73. The sliding member or tip member 31 attached to the forward end of the inflatable bag member 3 pushes the clicks 71 with the intertial force of its motion and then is caught by the clicks.

In Figure 7, the guide means is the means 60 which is adapted to guide in a predetermined direction the cord 55 which is thrust forward at a very high speed by the launching of the tip 34 or cap 35 mounted on the gas generating means 44 as shown in Figures 9 and 10. The means 60 is generally formed of pipes or solid bars. There may otherwise be adopted rails having a special cross section matching that of legs attached to the cord member 55 or some other similar articles which are suitable for the guidance of the cord member. In place of pipes, solid bars and rails of a special cross section, there may be used pulleys adapted to change the travelling course of the cord member as required. These guiding means are generally fastened on walls, for example, by such suitable fastening means as wooden screws, bolts or adhesive. Usually, the guide means is disposed along the entire length of travel of the cord. Where the cord need not be guided after it has been pointed in a predetermined direction, the guide means may be disposed over a part of the length of travel.

In Figure 13, the guide means refers to the means 160 which is adapted to guide in a predetermined direction the cord 144 which is drawn out at high speed by the projection of part of device 170, described in detail below with reference to Figure 20. This guide means is generally formed of angular pipes possessing an opening 163 on the lateral side and of sliding means 165 which slides in said pipes, as shown in Figures 17 and 19. There may otherwise be used hollow pipes having a cross section matching that of the sliding member 165 serving to hold down the cord member 144. In the case of the personal safety device using a net or cloth as shown in Figures 13 and 22, the guiding means 160 illustrated in Figure 19 may be provided at the end portion 162 thereof with a direction turning device 164 which comprises rollers adapted to change the travelling direction of the cord 144 as required.

In case of using cushioning bag as a cushioning means, the guide means further operates to restrain the movement and deformation of an inflatable cushioning bag due to the impact of the occupant against it.

The projecting means used in the system of the present invention is a means which moves along the guide means upon a signal from the sensing means immediately after the accident or collision and causes the

cushioning bag to be positioned and expand in front of the occupant. There are two kinds of mechanism for such a projecting means: one of which makes use of the force of an expanding tubular inflatable bag into which gas is introduced from the gas generating means; the other of which shoots a projectile with a cord attached by the pressure of the gas from the gas generating means or explosive powder so that the cord attached on the projectile may pull the cushioning means to the desired position. Further, these projecting mechanisms can be divided into pushing-out devices and drawing-out devices, depending whether the cushioning means is pushed or drawn out at the time of operation.

Referring to the attached drawings, the projecting means will be explained in more detail. A tubular inflatable bag 3 as shown in Figures 3 and 4 is extended and driven forward along guide means 5 by the gas produced at gas generating means and acts as a pushing device as in Figure 1. Figure 10 shows a drawing device in which a projectile is shot by the pressure of the gas produced by the gas generating means, so that the cord attached to projectile pulls and opens the cushioning means. Figure 20 shows a drawing-out device in which a projectile is shot out by the propellant power produced from the explosion of explosive powder, so that the cord attached to the projectile pulls and opens or expands the cushioning means. In Figure 9, there is shown a drawing-out device in which the inflatable bag member and projectile are used together.

The tubular inflatable bag member 3 is made from flexible and relatively light material, for example, cloth of natural or synthetic fibres, synthetic resin film and rubberised cloth. While the inflatable bag member of a cylindrical shape will prove to be most suitable, it may have an elliptical or a rectangular cross section. Preferably one end of the inflatable bag member 3 is fastened to the projection tube 8 provided with gas generating means 4 and the other end thereof is provided with a sliding tip member 31. On the other wall, the inflatable bag member 3 is provided with hooks or some other similar means designed to hold the cushioning bag 6 in position.

The projection device illustrated in Figure 10 comprises a cap, 35 provided with a cord 55, at one end of a projection tube 88 having gas-generating means 44. The cap 35 is made from relatively light material, such as metal, wood, or plastics material and has a streamlined shape suitable for projection such as a cone. Normally it is set in position outside the projection tube. The cord 55 may be a solid or hollow cord, rope, cable or net using natural or synthetic fiber, plastics material or light metal material. It is required to have a relatively light weight, flexibility and strength sufficient for the intended use.

As shown in Figure 20, it is possible to use a card-drawing device whereby a projectile is shot out by the propellant power produced by the explosion of an explosive powder. This drawing-out device 170 has a tip 171 slidably mounted in a support 176. A cord 144 is fastened to the tip 171 by a head 175. A gas generating means 174 is provided for projecting the tip. Both the tip and the support are bored to receive the cord 144. Inside a tapered hollow portion 177 screwed to the support 176, there are at least two separated stop wedges having a tapered shape corresponding to the hollow and teeth at their inside surfaces which engage with the cord 144. The stoppers 173 are prevented from undue forward movement on projection of tip 171 to draw out cord 144 by a spring 172. When movement of the cord ceases, the spring 172 forces the stop wedges into contact with the cord by a cooperating wedge action with the tapered hollow.

When the sensor 10 (Figure 24) detects a collision through the increased acceleration, the gas generating means 174 is actuated by a signal from the sensor via a wire 178 and produces gas. Due to the pressure of the gas and the consequent propellant power, the tip 171 is launched forward. As a result of the movement of the tip 171, the cord 144 is drawn out together with the attached cushioning means 120. The tip 171 is projected until the cushioning means of net or cloth 120 is opened enough to confine the occupant's body. It is possible to control the tip so that it does not run longer than necessary for confining the occupant's body. The cord 144 is apt to go slack due to the inertia of the confined occupant's body pulling the cord back through the device 170 when the movement of tip 171 has stopped. However, as mentioned above, at least two stop wedges 173, supported with spring 172, are provided with teeth at their facing surfaces to grip the cord so that it is restrained from movement backwards. Such means including a stopper mechanism to keep the occupant's body confined is called a "tightening device".

While this tightening device is in operation, the occupant can not get out of the seat. Therefore, it is necessary to provide a detaching device. A detaching means, denoted 200, may be provided at one point in the length of the cord member. The detaching means facilitates the release of the occupant's body from the seat immediately after the accident. The detaching means may be a means for severing the cord. One example of this detaching means is now ex-

plained with reference to Figure 21. Numerals 144 and 144¹ denote the two parts of the cord member and 202 denotes a severing tube which incorporates a joint 203. The joint 203 is strong enough to withstand the load likely to be applied thereto so long as the pack of severing explosive 201 remains intact. Numeral 204 denotes an electric conductor leading to the pack of severing explosive 201. Ignition of explosive 201 breaks the joint 203 and severs the tube 202 and cord 144. This detaching means is so designed as to effect the severance of the cord at a fixed interval of time (such as about one second) after the moment of accident by means of an electric signal from the sensor serving to detect the impact of collision of the vehicle. The outer cylinder of this detaching means 200 serves to prevent broken pieces of the detaching means from flying out and harming the occupant at the time of severance of the cord.

A drawing out device 40 adapted to be thrust forward by gas generating means 4 so as to draw cord 55 is illustrated in Figures 7 and 9. The cord 55 is attached to a cap 34 which fits in one end of the projection tube 88. The cap 34 also forms one end of an inflatable tube 33 gathered around the projection tube 88. Operation of the gas generating means inflates the tube 33 and projects the cap 34 outwards, drawing the cord 55 with it. The inflatable bag 33 used for this purpose is made of the same material and has the same construction as the aforementioned tubular inflatable bag member 3 (Figure 1). The cap is made of a relatively light material such as metal, wood or plastics substance and has a shape such as a cone suitable for projection. Normally, it is set in position inside the projection tube.

As gas generating means 4 and 44, there is used a chemical agent capable of producing a gas upon chemical reaction, or an explosive powder, or high pressure gas or gas under pressure. Also, for the gas generating means 174, there can be used chemical agent capable of producing gas upon chemical reaction, other than explosive agent.

The sensor used in the present invention may be any of the conventionally known ones so far as it functions to detect an acceleration over a predetermined level caused by collision of the high-speed travelling vehicle. It may be disposed on a vehicle as shown at 10 in Figure 24.

Now, several embodiments of the present invention are described in full detail.

Figures 1 to 6 inclusive show one embodiment wherein a cushioning bag 6 is used as the cushioning means and the tubular inflatable bag 3 attached to the cushioning bag 6, and adapted to be expanded and driven along a guide means 5 by the pressure of the gas from a gas generating means, is employed as means for projecting the cushioning bag 6 into the correct position. Numeral 1 denotes the occupant to be protected, 2 the seat accommodating the occupant, 3 the tubular inflatable bag normally stowed in a folded state, and 3a the tubular inflatable bag 3 in its expanded state. Numeral 31 denotes a sliding member whihch may be provided to contain the projecting means along the guide means 5, 4 and 41 the gas generating means, 6 the inflatable cushioning bag serving as the impact cushioning means and normally stowed in a folded state, and 6a the same cushioning bag 6 in its inflated state. Denoted by 7 is a stopper mechanism which may be provided if necessary. The cushioning bag 6 is joined to the tubular inflatable bag member 3 with fixing material 36.

When the sensor 10 (Figure 24) detects a collision of the high-speed travelling vehicle, it emits an electric signal which instantaneously actuates the gas generating means 4 and 41 so that the pressure of the gas will expand and drive forward the tubular inflatable bag member 3, causing the cushioning bag 6 to extend and be inflated simultaneously. The tubular inflatable bag 3 advances along the guide means 5 and the sliding member 31 eventually engages the stopper mechanism 7 provided at the terminal end of the guide means 5. The cushioning bag 6 is advanced simultaneously with the forward thrust of the tubular inflatable bag 3 and finally expanded to full capacity in front of the occupant. The expansion of the cushioning bag 6 in front of the occupant can be effected more smoothly by slightly delaying the time for actuating the gas generating means 41 which inflates the cushioning bag 6 with respect to the time for actuating the gas generating means 4 which inflates the tubular bag 3. This minute time lag can easily be accomplished by incorporating a delay detonator in the fias generating means.

Embodiments of the inflatable bag serving as projecting means and of the mechanism for driving, guiding and immobilizing the said bag as illustrated in Figures 1 and 2 are described with the aid of Figure 3. This is a cross section illustrating the construction of the inflatable bag in its normal folded state together with its accessories. Denoted by 3 is the folded inflatable bag member. One end of the bag 3 is fastened to the bottom of a projection tube 8 by means of a fastening ring 9 or adhesive agent and the other end is fastened on the optionally disposed sliding member 31 by a fastening ring 91 or adhesive agent. Normally, the inflatable bag 3 is folded and kept on the projection tube 8 and the sliding member 31 is inserted partially in the projection tube 8.

The gas generating means 4 is placed inside the projection tube 8. It releases the gas instantaneously at the moment that the sensor 10 detects the shock of collision. The sudden generation of gas causes the sliding member 31 to advance along the guide means 5 formed of pipes or solid bars. In consequence, the inflatable bag 3 is expanded and advanced. Thus, the cushioning bag 6 (Figures 1 and 5) joined to the inflatable bag 3 is thrust forward simultaneously with the motion of the inflatable bag 3.

The guide means 5 is generally provided, at its end portion, with a suitable stopper mechanism adapted to trap the forward end of the oncoming inflatable bag 3. One example of such mechanism is illustrated in Figure 4. A click 71 is rotatably fastened with a pin onto a support member 72. The support member 72 is provided with a notch designed to prevent the click 71 from moving further backward. A spring 73 exerts pressure so as to prevent the click 71 from inclining forward when in an inoperative state. When the sliding member 31 is thrust forward along the guide means 5 in consequence of a collision, the sliding member 31*a* pushes the click 71 back by overcoming the resilience of the spring 73 and is held fast by the stopper mechanism.

In the embodiment illustrated in Figure 3, the guide means 5 is supported in position only at each end. When the inflatable bag 3 and the sliding member 31 are desired to be guided along a complex path, it becomes necessary to immobilize the guide means by fastening it at other suitable points to the vehicle. In one method, rails having a special cross section are employed as the guide means 5 and are fastened onto the wall at several points selected for changing direction, so that the inflatable bag and the sliding member thereof may be attached freely slidably onto the rails by fastening rings having legs adapted to slide along the rails. Thus, the inflatable bag and the sliding member can be guided simultaneously along the grooved rails. As an alternative, there may be adopted a method whereby the guide means 5 may be formed of a suspended rail (monorail) fixed at desired points so that the inflatable bag may be guided by a sliding member designed to slide along this suspended rail.

Figure 5 is a perspective view illustrating the relationship between the inflatable bag 3 and the cushioning bag 6 which are stowed in their normally folded state. Figure 6 is a cross section taken along A—A line given in Figure 5. The backward end of the cushioning bag 6 is fastened to a supporting plate 81 for the gas generating means 41. The inflatable bag 3 and the cushioning bag 6 are joined to each other suitably at the plane of their engagement. In this case, it is imperative that they should be joined so that their folded portions can be expanded freely when they are set into motion. As a consequence, when the inflatable bag 3 is thrust forward and expanded along the guide means 5, the cushsioning bag 6 is simultaneously thrust out and expanded at the predetermined place.

Figures 7 to 12 inclusive illustrate another embodiment wherein the cushioning bag 6 shown in Figure 1 is employed as the cushioning means. A drawing-out device 40 causes a cord 55 attached to the cushioning bag 6 to be thrust forward by the pressure of the gas from the gas generating means 44 so as to draw forth the said cushioning bag 6 and thus acts as the means for projecting the cushioning bag 6 to its operative position. In the diagrams, 1 denotes the occupant to be protected, 2 the seat accommodating the occupant, 33 a tubular inflatable bag normally stowed in a folded state, and 33*a* the same bag now in its expanded state. Numerals 44 and 45 denote the gas generating means, 55 the cord having one end stowed in a folded state, 60 the guide means, 61 the sliding member for guiding the cord 55 along the guide means 60, 62 a pulley designed to change the direction of motion of the cord 55, 6 the cushioning bag normally stowed in a folded state, and 6*a* the same cushioning bag now in its inflated state. The cushioning bag 6 is joined with fixing material 52 to the folded portion 51 of the cord 55. When the sensor detects the shock of a collision of the high-speed travelling vehicle, the gas generating means 44 and 45 are instantaneously actuated to release the gas, causing the tubular inflatable bag 33 to be expanded and thrust forward and the cushioning bag 6 to be expanded. The cord 55 set in motion by the inflatable bag 33 proceeds along the guide means 60. The cushioning bag 6 advances simultaneously with the motion of the cord 55 so as to be expanded to its fully inflated state in front of the occupant. The expansion of the cushioning bag in front of the occupant is accomplished most smoothly by slightly delaying the time for actuating the gas generating means 45 which inflates the cushioning bag 6 with respect to the time of actuating the gas generating means serving to drive the tubular inflatable bag 33. This minute time lag may be easily accomplished by incorporating a delay detonator in the gas generating mechanism.

Embodiments of the drawing-out device 40 for the cord member 55 are described with reference to Figures 9 and 10. Figure 9 is a cross section illustrating the construction of the inflatable bag in its inoperative state and of the accessories therefor. In the

diagram 33 denotes the inflatable bag member, one end of which is fastened to the bottom end of a projection tube 88 made of such material as metal, wood, or a plastics substance and provided at the bottom center with a hole through which the cord 55 passes. At the other end of the tubular bag is optionally incorporated a tip member 34. In its inoperative state, the inflatable bag is folded over the projection tube 88. The tip member 34 is inserted partially in the projection tube 88. Numeral 44 denotes the gas generating means disposed inside the projection tube 88. It generates gas instantaneously the moment the sensor 10 (Figure 24) detects the shock of a collision. The sudden generation of gas thrusts forward the inflatable bag 33 and the tip member 34, causing the cord 55 to be drawn forward similarly at very high speed. Consequently, the cushioning bag 6 (Figures 7 and 8) joined to the cord 55 is caused to advance simultaneously with the cord 55.

Figure 10 is a cross section illustrating the construction of another embodiment of the projecting means, in which the cushioning means is drawn out by a cord. In the diagram, 35 denotes a cap which is fastened partially on the projection tube 88 in its inoperative state. The pressure of the gas delivered by the gas generating means 44 launches the cap 35 as a projectile with the result that the cap will draw the cord 55 with it.

In the cross-sectional diagram of Figure 11, 63 denotes a guide means formed of a suspended rail. The cord 55 is fastened onto a sliding member 64 having the shape of a horseshoe. This sliding member 64 advances along the suspended rail (monorail), 63.

Figure 12 is a cross section illustrating another embodiment of the guiding means. In the diagram, 65 denotes a guide means formed of a rail having a special cross section. The cord 55 is fastened to a T-shaped sliding members 66 which advance along the rail 65.

Figures 13 to 21 inclusive illustrate still another embodiment of the personal safety system, wherein a net or cloth 120 is employed as the cushioning means. A drawing out device 170 designed to project a tip 171 by explosive 174 is used as the projecting means for drawing out the net or cloth 120 by a cord 144 attached to the tip 171 by a head 175. This opens the net or cloth 120, which is then held fast in the unfolded and spread state by causing the cord 144 to be drawn along guide means 160. In the diagrams, 1 denotes the occupant sitting on the seat 2 of a high-speed travelling vehicle such as an automobile, 130 the protective net housing fastened to the upper side of the vehicle interior or to the ceiling above the occupant's seat, and 120 the personal protection net stowed in the case 130. The personal protection net 120 serves the purpose of confining and protecting the occupant 1 when it is unfolded and spread to the state indicated at 120*a* in front of the occupant and held tight in that unfolded state. This net may be made of nylon. In its inoperative state, the net is suitably stowed in a folded form inside the net case 130. The protection net 120 is provided at each end thereof with a cord or a strip 121 as illustrated in Figure 15. The guiding means 165 are fastened to the lower end thereof via the connectors 166. The sliding members 165 are disposed so that the protection net or cloth 120 is drawn out and unfolded to its operative state by the advancing motion of the sliding members along the guide rails 160. The cords 144 are fastened to the sliding members 165, passed through the interior of the guide rails 160 and connected to the cord drawing device 170 which is disposed either under the seat 2 or outside the vehicle interior as illustrated in Figure 13. As shown in Figure 20, the cord drawing device 170 comprises a tip member 171 thrust forward by the explosion of explosive 174 so as to draw out the cord 144, a spring 172 designed to cooperate with stop wedges 173 to prevent the cord 144 from travelling backwards upon completion of the drawing out. When the sensor 10 (Figure 24) detects the shock of a collision, the tip member 171 is thrust forward by the propellant power from the gas generating means 174 so as to draw out the cord 144 attached to the protecting net or cloth 120, with the result that the protecting net or cloth 120 will be opened or expanded to its operative state.

As is clear from Figures 13, 16 and 17, the guide rail 160 is provided at the end portion 162 thereof with a sliding member direction-turning device 164 incorporating a roller 161. A cord or belt member 121 is fixed on each side of the protecting net or cloth 120. The sliding member 165 fastened to the cord or belt member 121 via the connecting member 166 leads or draws the net 120 while sliding inside the guide rail 160. The size of this sliding member 165 is such as to permit smooth sliding travel inside the guide rail 160. The connecting member 166 slides along the groove 163 formed in the guide rail 160. As the sliding member 165 reaches the net or cloth direction-turning device 164 after having slid inside the guide rail 160, it is detached from the guide rail 160 by virtue of a push from the roller 161. Since the detached sliding member is no longer restricted by the guide rail 160, it changes the direction of travel and at the same time the cord drawing device 170 causes it to move in the direction of the

seat 2. Thus, the cord 144 and consequently the protecting net or cloth 120 are tightened up. The sliding member 165 will not under any condition come into direct contact with the occupant's body since the guide rails 160 is place on each side of the vehicle interior.

The personal safety system illustrated in Figures 13 and 14 is explained with respect to its operation. When the high-speed travelling vehicle is involved in an accident such as a collision, the sensor 10 (Figure 24) mounted on the vehicle issues a signal to ignite the explosive 174 planted in the cord drawing devices 170 disposed at the lower part of the vehicle. The explosion causes the tip members 171 to fly in the predetermined direction. Since the cords 144 are fastened to these tip members 171, they are simultaneously drawn out. The sliding members 165 which are fastened to the cords 144 are simultaneously drawn out, sliding inside the guide rail 160. Consequently, the protecting net or cloth 120 which is connected to the sliding members 165 via the connecting member 166 is drawn downwardly out of the case 130. The protecting net or cloth 120 thus drawn out of its case is immediately expanded as the sliding members 165 attached to the lower corners thereof lead and guide the cords 144 and slide inside the guide rails 160. As the sliding members 165 reach the sliding member direction turning device 164 disposed at the end of the guide rails 160, they are detached from the guide rail 160 by virtue of a push from the roller 161. The detached sliding members 165 are no longer restricted by the guide rail 160. The cord drawing device 170 causes the detached sliding members to change their direction of travel and advance in the direction of the seat 2. From this point on, the cord drawing device 170 begins to tighten the cords instead of drawing them. This tightening action of the cord drawing device 170 tightens up the cords 144. As a consequence, the protecting net or cloth 120 which has been expanded by the motion of the sliding members 165 along the guide rails 160 confines the occupant's body completely so as to prevent the occupant from colliding into the wind shield or other accessories and sustaining inpuries. When the occupant's body comes into contact with the protecting net or cloth 120 which has been expanded to its operative state, the cord 144 is not permitted to move backward because the cord drawing device 170 is provided with a return stopping means comprising the spring 172 and the stopper 173. The pressure exerted by the occupant's body only serves to ensure the tightening of the protecting net 120. Thus, the occupant's body can be confined perfectly.

It is possible for the occupant to get out of seat 2 with the help of detaching means 200 as shown in Figure 21. When the movement of the occupant is stopped, the previously set sensor 10 (Figure 24) actuates the explosive pack 201, so that joint 203 is severed and breaks the cord 144 from the cord 144, so that the occupant can easily get free from the net or cloth 120.

Figures 22 and 23 illustrate yet another embodiment where the net or fabric 120 is combined with a tubular bag 133 to form the cushioning means, and the drawing-out device 170 shown in Figure 20 is used as the projecting means for drawing out the said net or cloth 120 by the agency of the cord 144. In the diagrams, 1 denotes the occupant sitting in the seat of the high-speed travelling vehicle such as an automobile, 130 polyethylene cases disposed stationarily above the seat such as, for example, on the ceiling of the vehicle, and 133 a tubular inflatable bag member made of rubberized nylon fabric. As shown in Figure 23, two or more tubular inflatable bag members are provided on the sides. The net or cloth 120 made of such material as nylon and designed to confine the occupant's body is fixed between the tubular inflatable bags 133. In its inoperative state, this net or cloth 120 is stowed in a folded state inside a compartment 131 of a large width communicating with the cases 130. It is expanded to the operative state indicated at 120*a* of Figure 23 in consequence of the elongation of the tubular bags 133. A gas generating means 180 using explosive as the gas source is placed inside each tubular inflatable bag member 133. The igniting device for the gas generating means is interlocked with the sensor 10 (Figure 24). To the tip of the tubular inflatable bag members 133 is fastened a cord 155 made of such material as nylon. The cord 155 is passed through the guide 160 via the personal safety net sliding member 156 and fastened to the rope 144 which is connected to the cord drawing device 170 (Figure 20) disposed below the seat or outside the vehicle interior. The guide 160 tightens the personal safety net or cloth 120 and the tubular inflatable bag member 133 before the occupant's body thrust forward as by the collision has collided into the seat or other hard object inside the vehicle. Consequently, the personal safety net and the tubular bags which are connected inseparably are allowed to expand amply. After the personal safety net or cloth has been drawn past the sliding member direction-turning device 164 provided at the end of the guide 160, the direction of its travel is changed toward the seat by the safety net or fabric guiding member 165.

The operation of the embodiment illus-

trated in Figures 22 and 23 is explained. When the high-speed travelling vehicle such as an automobile is involved in a traffic accident such as head-on collision, sideways collision or rolling, the sensor 10 (Figure 24) actuates the gas generating means 180. The resultant gas pressure instaneously thrusts the personal safety net or cloth 120 and the tubular inflatable bags 133 forward. At the same time, the tip 171 of the cord drawing device 170 is shot out beneath the vehicle by explosive force so as to draw out the rope connected to the said device 170. As a result, the personal safety net or cloth 120 and the tubular inflatable bags 133 are simultaneously drawn out and instantaneously spread out like a casting net or cloth in front of the occupant's body which is on the verge of being thrown forward, with the result that the occupant's body is confined safely. Consequently, the occupant's body is confined with perfect safety as illustrated in Figure 23.

It is possible for the occupant to get out of seat 2 with the help of detaching means 200 as shown in Figure 21. When the movement of the occupant is stopped, previously set sensor 10 (Figure 24) actuates to explode the explosive powder in severing explosive pack 201, so that joint 203 and cord member 144 are severed so that the occupant can easily get free from the net or cloth 120.

WHAT WE CLAIM IS:—

1. A personal safety system for an occupant of a motor vehicle comprising impact cushioning means being a sheet material, a net or an inflatable bag normally stowed in a folded condition and unfoldable to receive and absorb the impact of an occupant's body, projecting means for projecting the cushioning means to a position in front of the occupant, guide means to stabilize the cushioning means during unfolding thereof, and a sensor adapted to actuate the projecting means on sensing an acceleration exceeding a predetermined magnitude.

2. A system according to claim 1 in which the projecting means is a tubular bag normally stowed in a folded condition and inflatable by gas-generating means actuated by the sensor.

3. A system according to claim 1, in which the projecting means is a projectile launched by gas-generating means actuated by the sensor.

4. A system according to any one of claims 1 to 3, in which the impact cushioning means is an inflatable bag inflatable by gas-generating means.

5. A system according to any one of claims 1 to 3, in which the impact cushioning means is a sheet material or net provided with a means for tightening the sheet around the occupant.

6. A system according to any one of claims 1 to 5, in which the guide means is a guide rail slidably connected to the impact cushioning means.

7. A system according to any one of claims 1 to 5, in which the guide means is a guide rail slidably connected to the projecting means.

8. A system according to any one of claims 1 to 7, in which the projecting means is directly connected to the impact cushioning means.

9. A system according to any one of claims 1 to 7, in which the projecting means draws out the impact cushioning means by a connecting cord.

10. A system according to claim 2 or claim 3, or any claim dependent thereto, in which the gas-generating means is a gas stored under pressure or a chemical gas-generating composition.

11. A personal safety system for an occupant of a motor vehicle substantially as described herein with reference to Figures 1 to 6; 7, 8, 11 and 12 with 9 or 10; 13 to 21; or 21 to 23 of the accompanying drawings.

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Sheet 1

FIG. 1

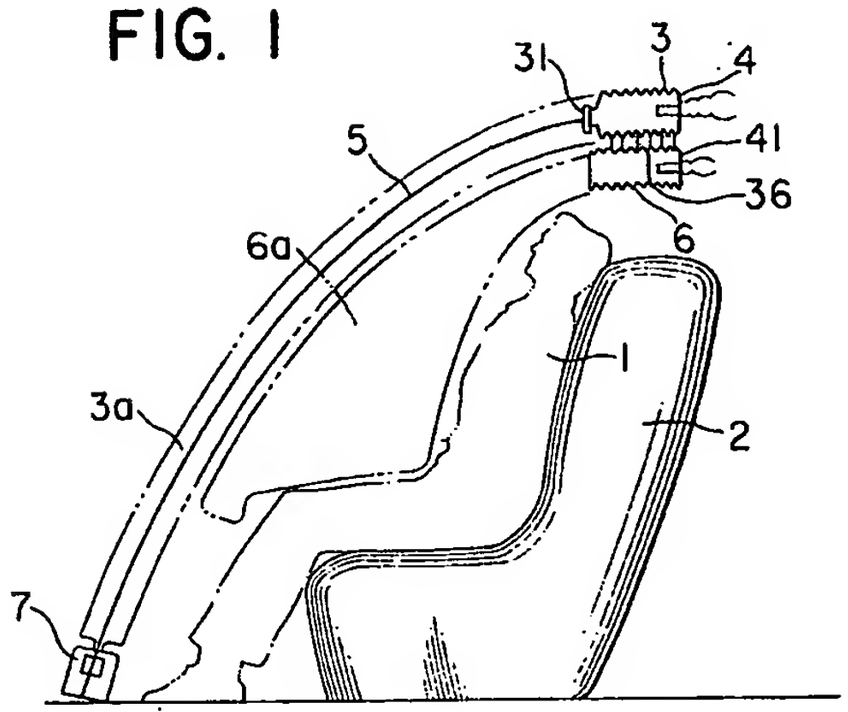


FIG. 2

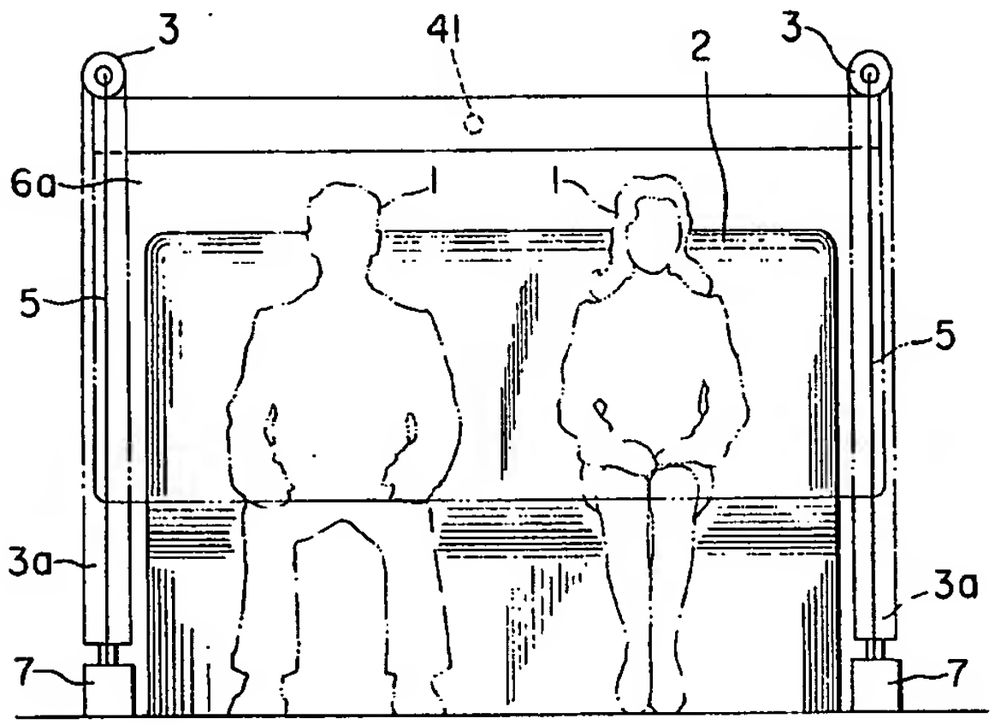


FIG. 3

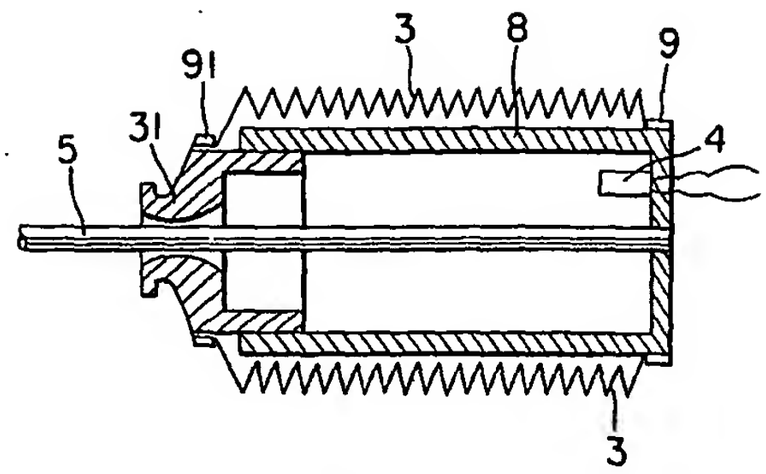


FIG. 4

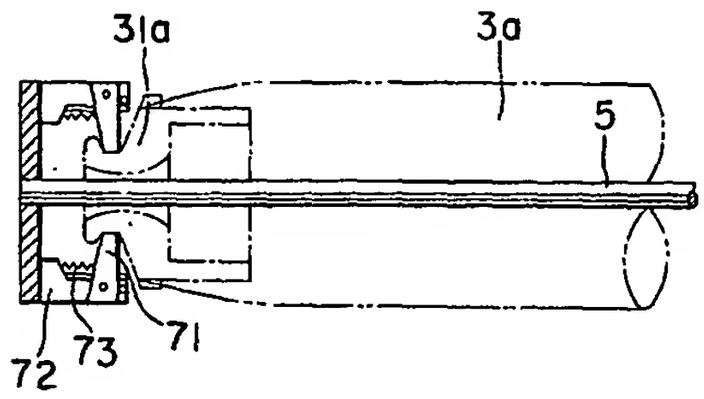


FIG. 5

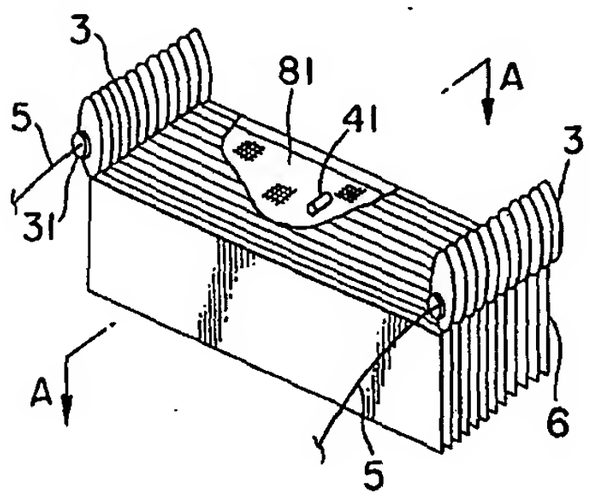


FIG. 6

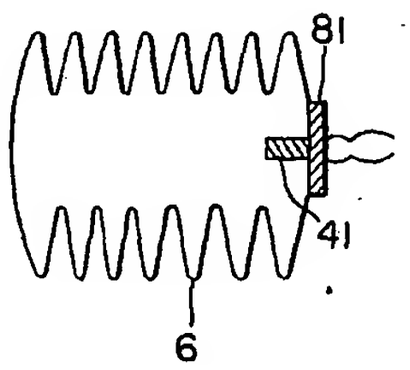
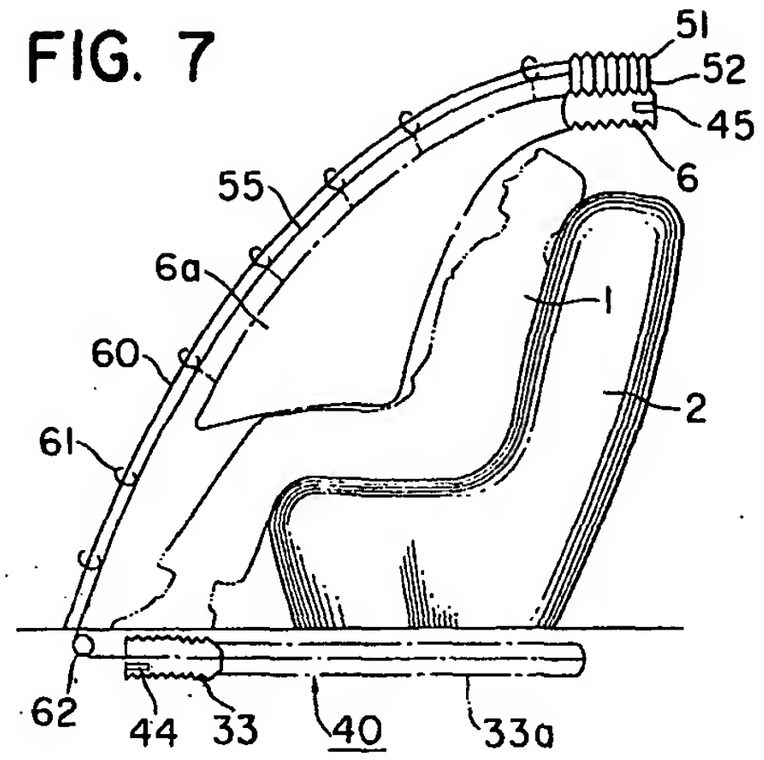


FIG. 7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33a

FIG. 8

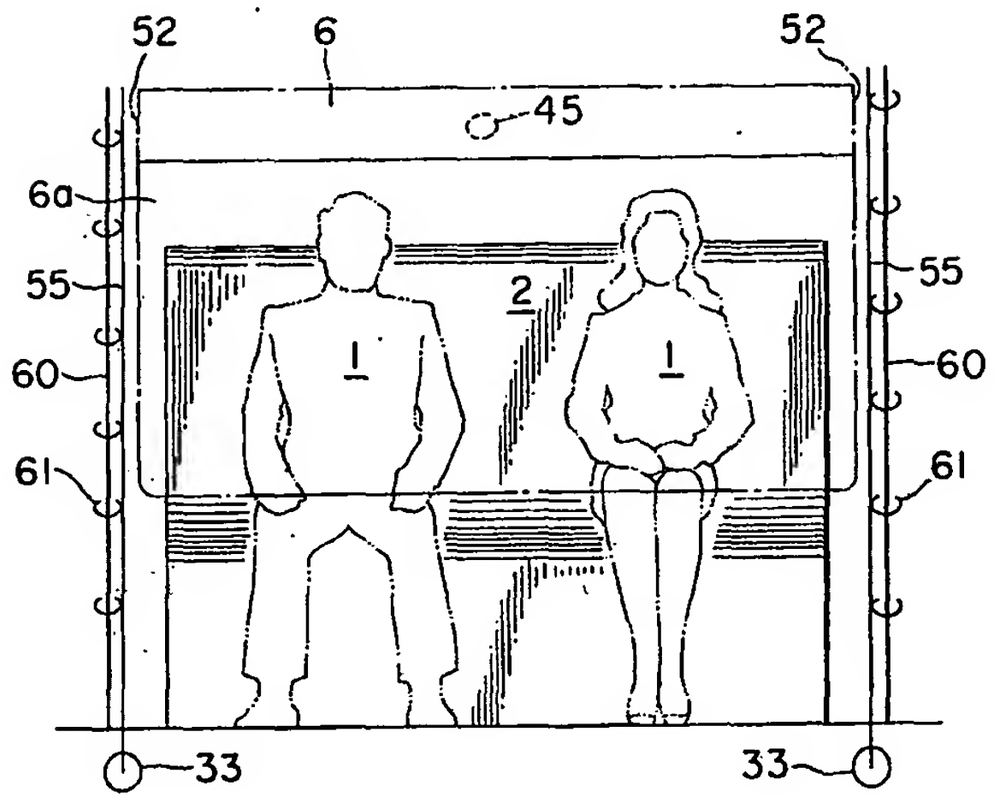
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FIG. 9

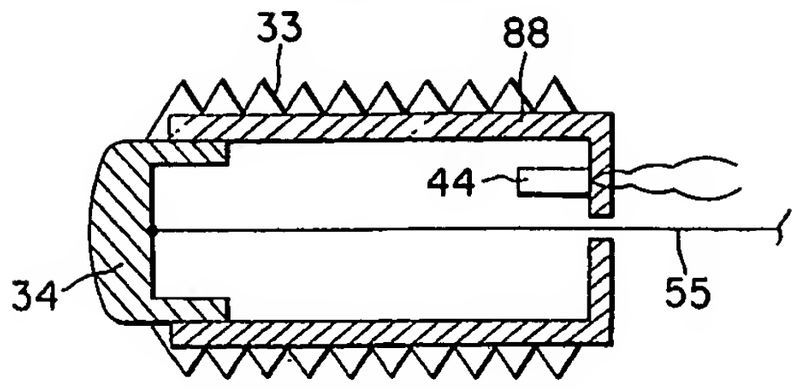

FIG. 10

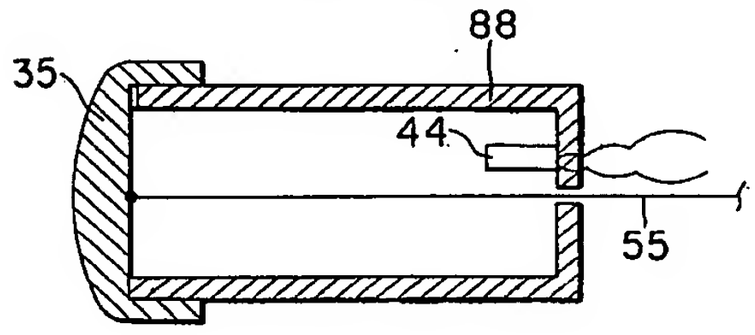

FIG. 11

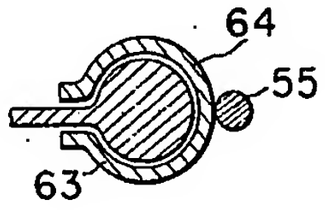

FIG. 12

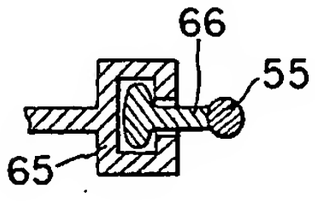

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FIG. 13

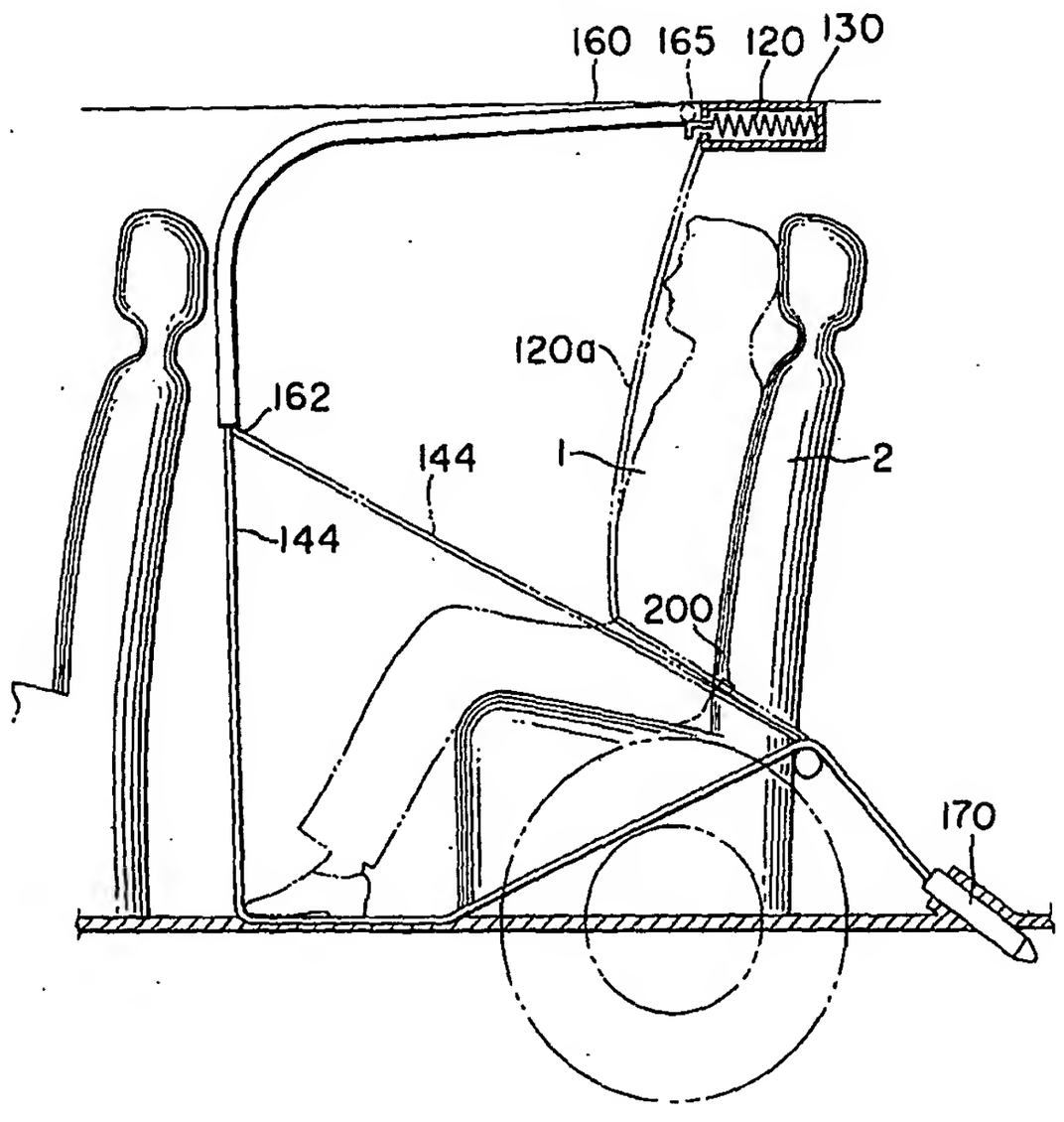


FIG. 14

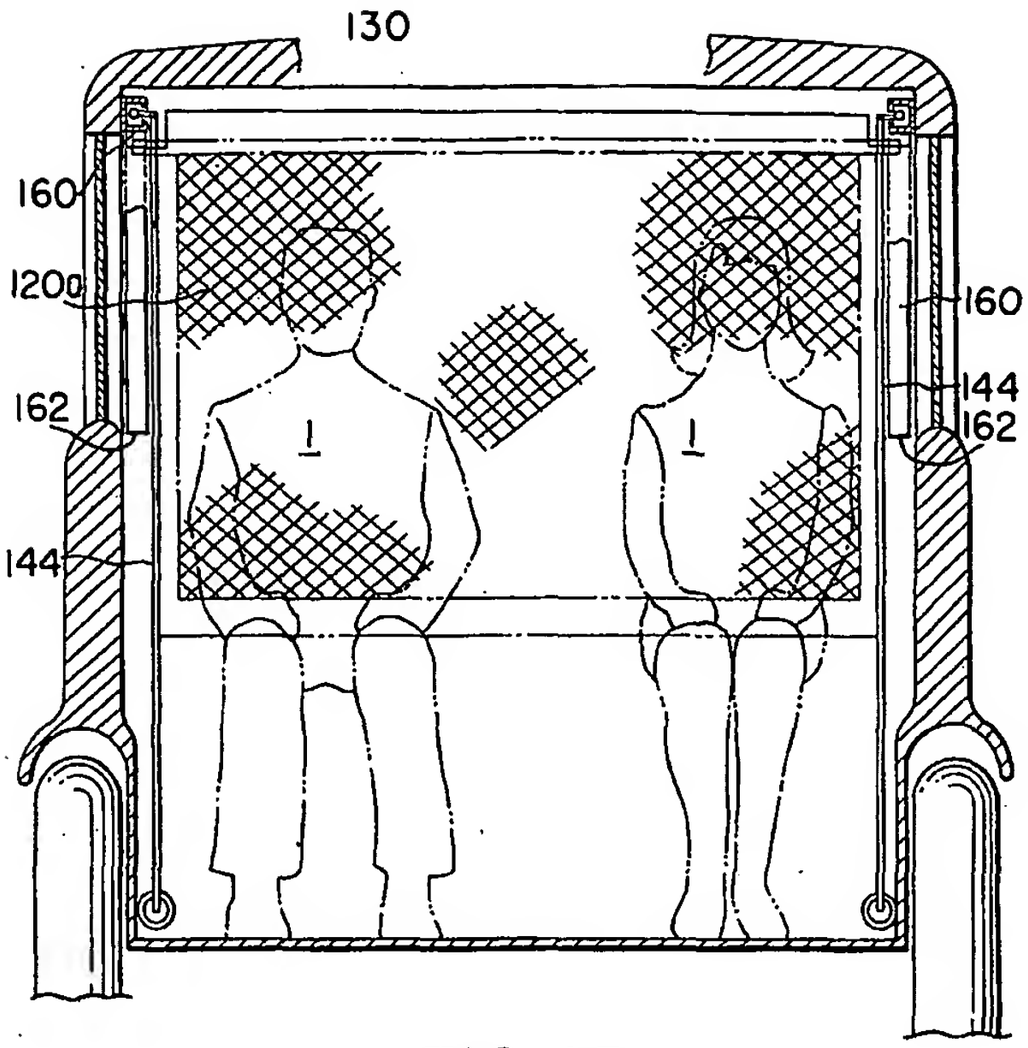
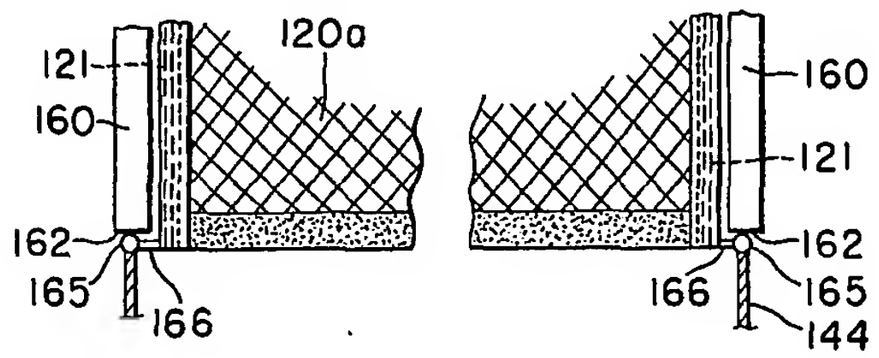


FIG. 15



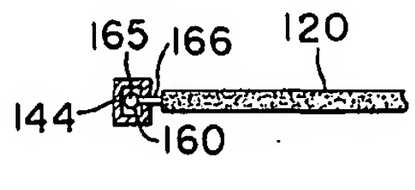


FIG. 16

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FIG. 17

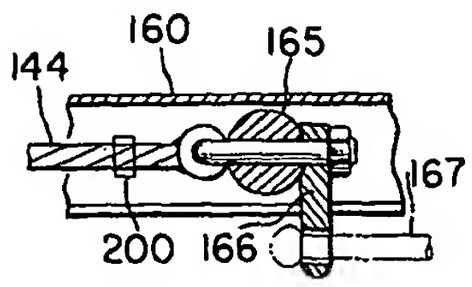

FIG. 18

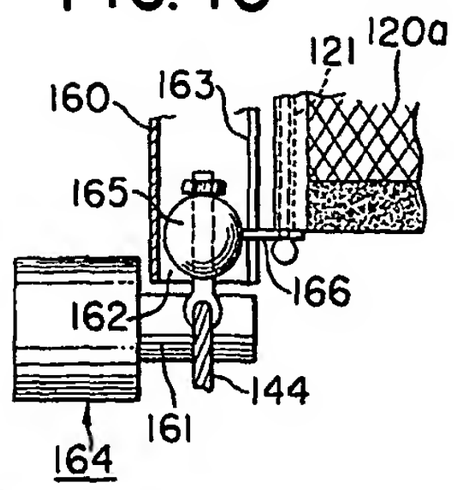

FIG. 19

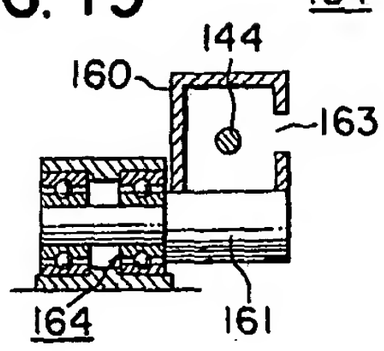

FIG. 20

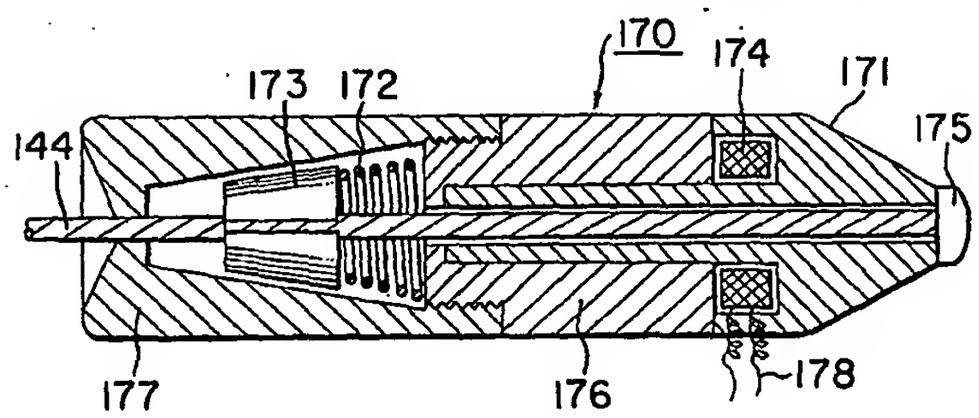

FIG. 21

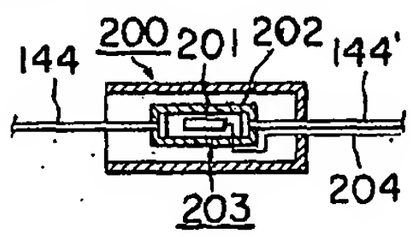

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FIG. 22

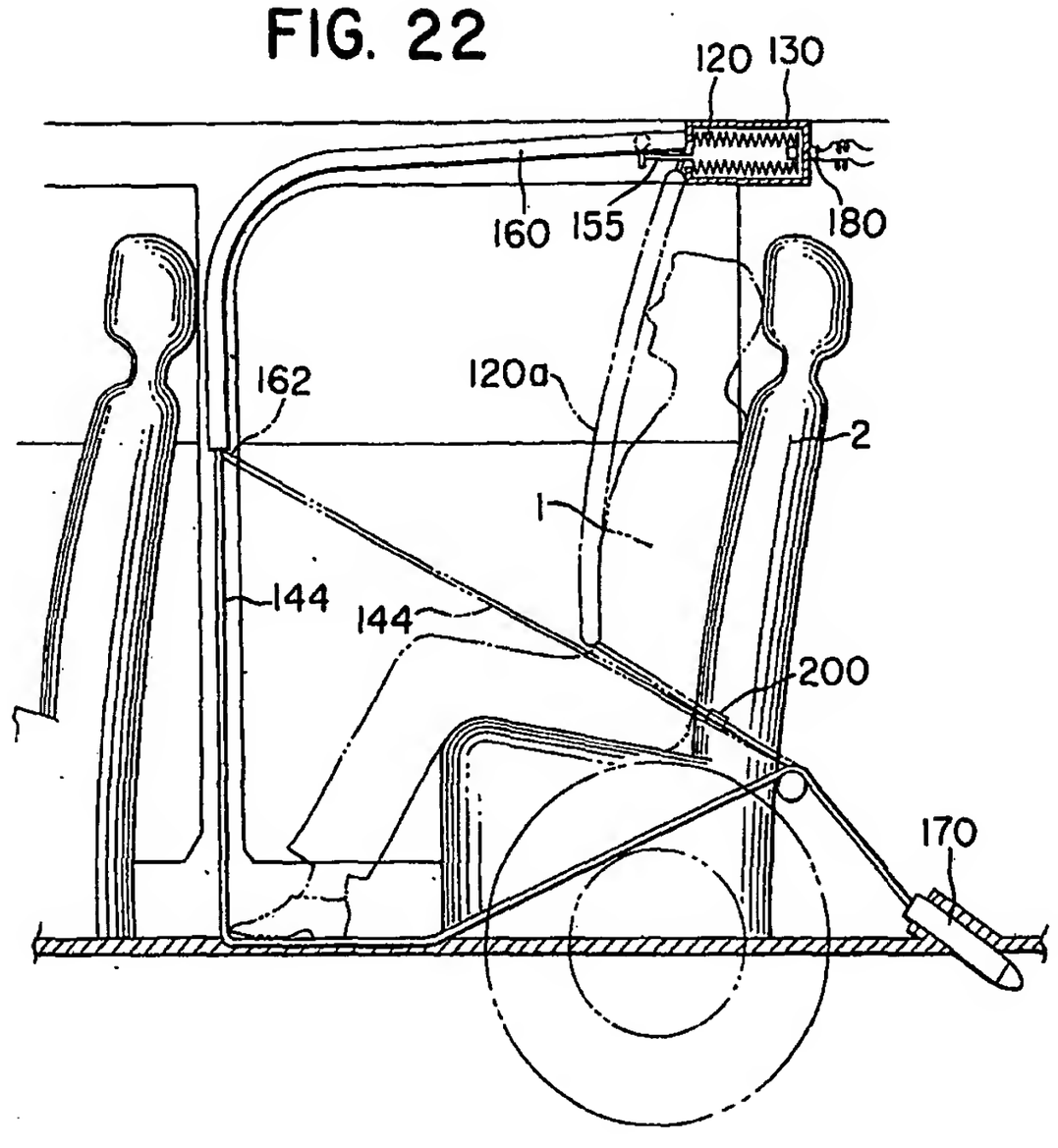

FIG. 23

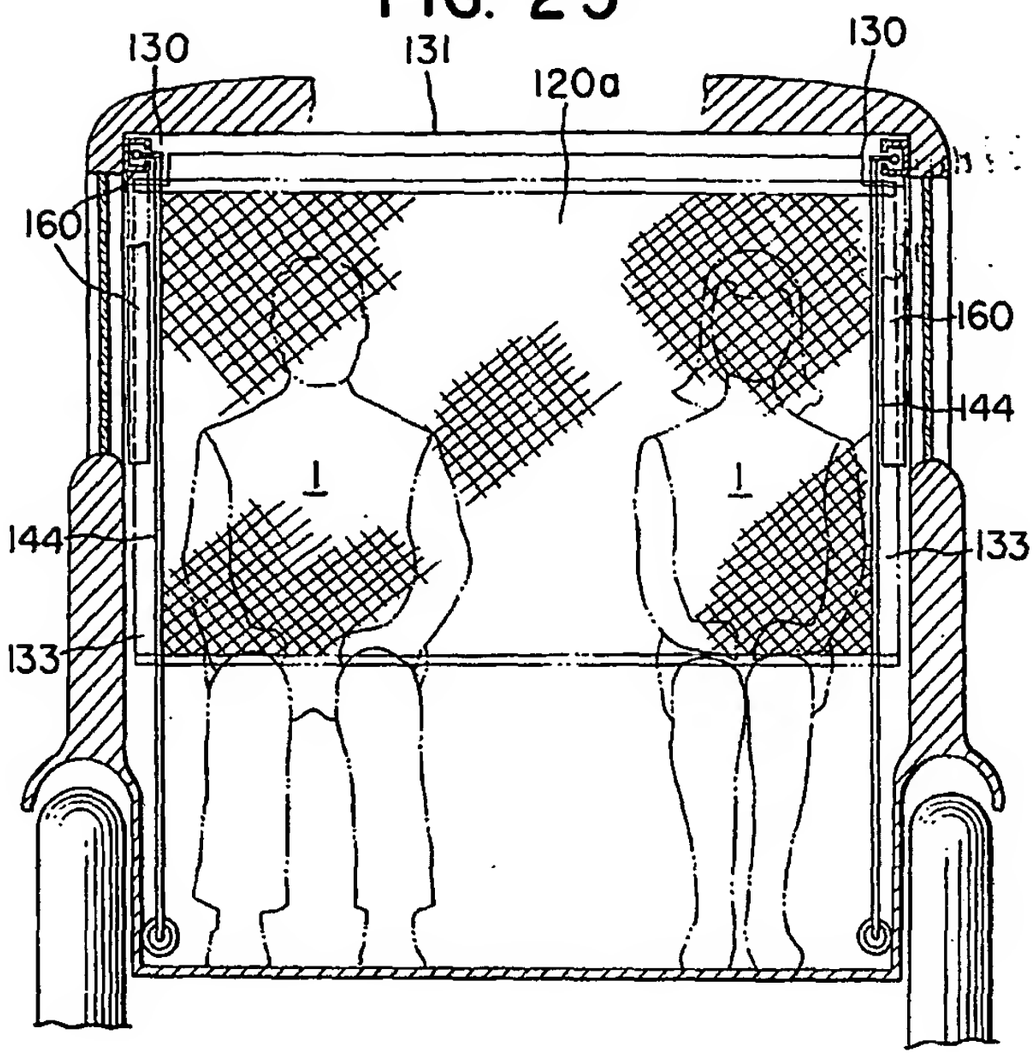

FIG. 24